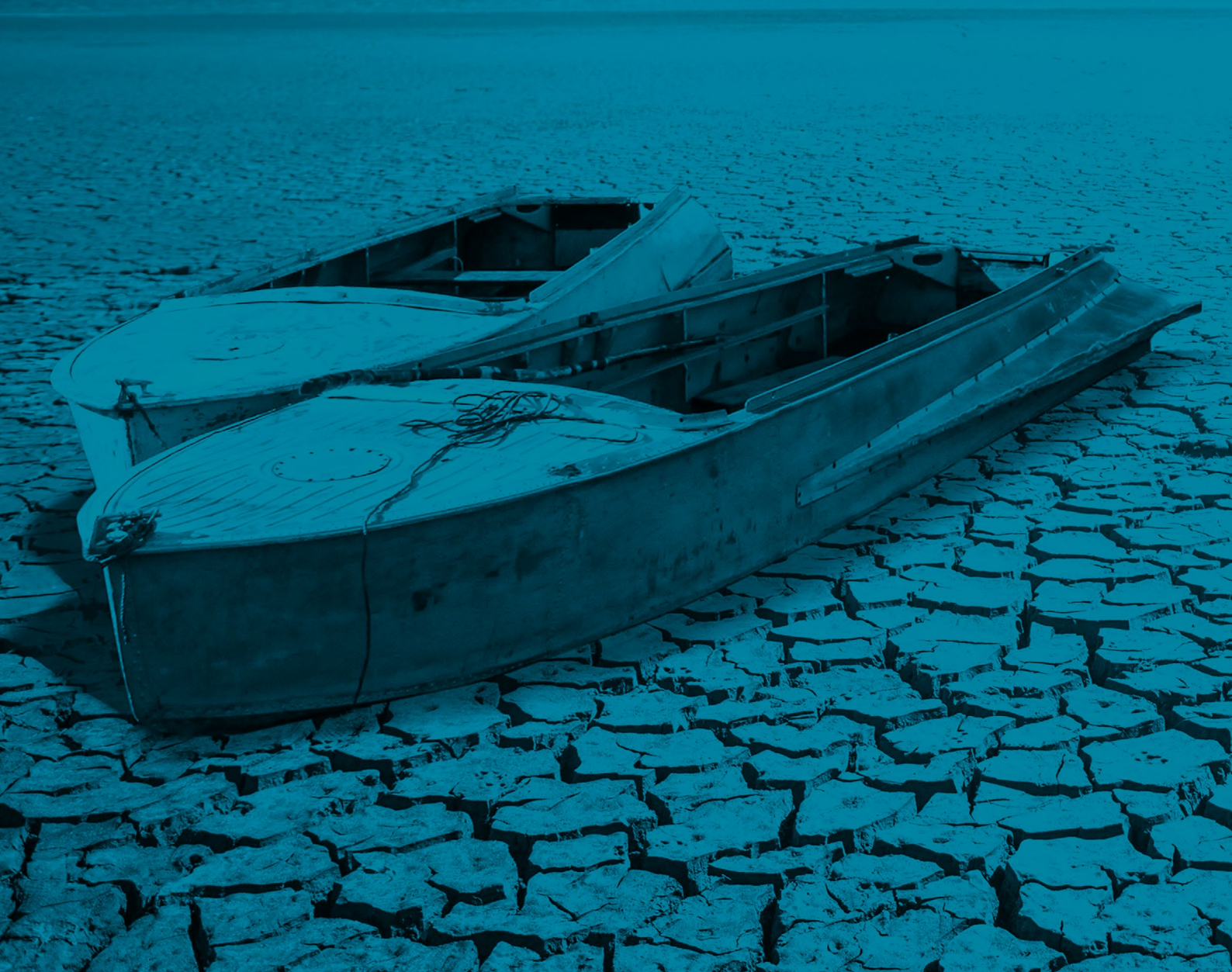
GUIDANCE NOTE 12

Programmatic Responses to Extreme Heat

Guidance for Humanitarian Practitioners



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Abbreviations

DRR	Disaster Risk Reduction
EWS	Early Warning System
FSL	Food Security and Livelihoods
HRI	Heat Related Illnesses
IYCF	Infant and Young Child Feeding
IPCC	Intergovernmental Panel on Climate Change
MNP	Multiple Micronutrient Powder
NCD	Non-Communicable Disease
NGO	Non-Governmental Organisations
RCCE	Risk Communication and Community Engagement
UHI	Urban Heat Island
VCA	Vulnerability, Capacity Assessment
WASH	Water, Sanitation and Hygiene

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Introduction

Climate change is increasing the risk of heatwaves – periods of dangerously high temperatures – around the world, and humanitarians are having to contend with this type of disaster, often for the first time. Heatwaves can appear less dramatic than some other hazards because they are generally less damaging to property and infrastructure, but they have extremely severe effects on health and mortality, as well as negative impacts on other areas of concern to humanitarians, such as livelihoods and nutrition.

This guidance provides information on the nature and effects of extreme heat.[1] As the humanitarian experience of extreme heat is still fairly limited, this information should be useful in helping readers to better understand key aspects of the threat. The information provided is based almost exclusively on peer-reviewed literature, prioritising literature that concentrates on low-income contexts and that reviews multiple sources (systematic and scoping reviews).

The guidance also identifies concrete actions that humanitarians can take – specifically in the sectors of Food Security and Livelihoods (FSL); Health; Nutrition; Risk Communication and Community Engagement (RCCE); Shelter; Water, Sanitation and Hygiene (WASH); and Protection – to prepare for and respond to heatwaves.[2]

Who is this guidance for?

This guidance is primarily intended for humanitarian actors: community organisations, Non-Governmental Organisations (NGOs), local and national governments, international organisations and others working in fragile and conflict-affected states. It may also be useful to organisations working in other low-resource contexts.

1 Extreme Heat – a Humanitarian Issue

Extreme heat is a relatively new threat for many humanitarian actors. While humanitarian organisations are well practised in preparing for and responding to hazards, such as flooding, tropical storms and droughts, much less attention has been given to extreme heat. This is changing, as heatwaves become more frequent and more deadly.

Extreme heat kills and has severe impacts on health

The Intergovernmental Panel on Climate Change (IPCC) has identified increased global temperatures as a key source of poor health [1, 3].

- Heatwaves – defined periods of extreme heat – 'are among the deadliest natural disasters' [4]. Reported death rates vary, depending on the location, severity, duration and approach to measurement, but in some cases mortality rates have increased by 33%[3] [18]. A systematic review of different sources showed increases in mortality from 3% to 28% during heatwaves [44] (for information on how heat kills, see Box 5: Heat and the human body).
- In the period 2012-2021, average annual heat-related mortality reached an estimated 546,054 deaths per year globally [126]. This is only slightly below estimated global deaths from malaria [127].[4] In countries with a low Human Development Index, heat-related mortality accounted for an estimated 1.73% of all deaths over this period [126].
- Extreme heat does not always kill – it also has severe effects on people's health, particularly the health of older people, people with disabilities, people with pre-existing and/or chronic conditions, pregnant women, infants and children, and people conducting physical labour (see Box 3: Vulnerability to heat).

Extreme heat also impacts other areas important to humanitarians, including nutrition, WASH and food security

- Extreme heat has also been shown to have severe effects on nutrition and to be associated with both stunting and wasting [36].
- Extreme heat has multiple negative effects on food security and livelihoods, including on crop production [45], livestock production [46, 47] and the ability to conduct wage labour [14].
- In the WASH sector, extreme heat also has negative effects, including increased demand for water [48], decreased water quality [49], and effects on the efficacy of chemicals used in treatment [50, 51].

These impacts will greatly increase in the near future

- As a result of climate change, exposure (measured in person days) to extreme heat has increased very significantly since the start of the century [37, 11]. Exposure for vulnerable groups increased by over 300% during the first quarter of the 21st Century [126].
- Associated mortality has also increased significantly, rising by 63% over the same period [126, see also 10, 11, 12].
- By 2035,[5] the frequency of heatwaves globally is predicted to be 8.6 times higher than it was before the industrial period (and the onset of climate change) [40]. This increased frequency can be expected to lead to greatly increased mortality [13].
- Increases in heat are also forecast to have extremely negative effects on nutrition [36] and will contribute to negative impacts on food security [52].

Many decision makers, as well as people at the highest risk, are unaware of the dangers of heat

- Many policy makers, service providers and members of the general public in countries at the highest risk are unaware of the dangers to life and health posed by heat. ‘High temperatures are often seen as something to be tolerated, rather than a major health risk’ [15, see also 8, 16, 58, 111]. The threats of heatwaves have been ‘largely overlooked’ [3] – although this is changing.

The negative impacts of extreme heat can be very significantly reduced through simple actions

- In some parts of the world, maximum temperatures are reaching the 'upper limits to survivability' [3, 128], which makes it almost impossible to decrease mortality without extensive use of cooling systems such as air conditioning.[6]
- But in most countries, heat-related mortality is currently largely preventable through a series of activities to minimise people's exposure and sensitivity to heat [9, 14].
- Evaluations have demonstrated that Heat Action Plans, which structure and organise activities such as passive cooling installations, rehydration, reduced exposure to sun, and other low-resource measures, can contribute to a reduction of illnesses and deaths from heat [21, 124].
- The activities that feature in most Heat Action Plans are low cost and fairly simple [20].

Box 1: Defining a heatwave

A heatwave is broadly understood as a period of weather that is unusually hot for a specific location, leading to negative human health outcomes [9]. However, establishing precise definitions for how long the 'period' must last or what constitutes 'unusually hot' is complex, as these criteria vary significantly from one country to another [6, 9, 23, 43].

The danger of heat is not linked to a single, universal **temperature**; it is relative to the climate that a local population is accustomed to [2, 6, 20, 43]. Consequently, mortality rates may rise in one region at temperatures that would be considered normal in another. As a result of this geographical variation, heatwaves are generally defined as periods when temperatures are in the very highest ranges for that particular area at that time of year.

Atmospheric **humidity** can also strongly relate to the impact of heat on the human body (see Box 2: Not just the thermometer reading). For this reason, some—but not all—countries incorporate humidity into their heatwave definitions [9, 15, 16, 23]. There is, however, some debate about whether the physiological effects of increased humidity actually influence mortality rates during heatwaves [131].

Heatwave definitions also diverge regarding the required **duration** of the hot weather. In some cases, a heatwave can be defined as just a single day of hot

weather [9]. However, many countries define heatwaves as lasting two, three, or more days. This is because heat-related mortality has been observed to increase significantly in some cases over a multi-day period [6, 9, 23, 43]. Note also that the average duration of a (formally declared) heatwave occurring in a fixed location has been recorded in Europe as 4.5 days [67] and around 4 days in the USA. These are averages: there have been significantly longer heatwaves in both contexts. The average length of a heatwave in any one city in China during the 2022 country-wide heatwave was 13 days [68]. Heatwaves can also be part of much longer periods of hot weather, where temperatures do not quite reach the level required for a heatwave, but are still dangerously high. As heatwaves are atmospheric phenomena that move over time, when considering the duration of a heatwave, it is also important to differentiate between a heatwave occurring at a fixed point (such as an individual city) and the generally longer period over which a heatwave occurs in a region.

Some definitions of heatwaves also consider **seasonality**. Some evidence indicates that the timing of a heatwave matters: they seem to be more deadly when they occur earlier in the hot season [9, 20, 43]. A few definitions take this into account by setting different temperature thresholds for a heatwave depending on the time of year [9].

2 Five Principles for Humanitarian Organisations Addressing Extreme Heat

Although the threat of extreme heat is relatively new to many humanitarian organisations, some of the basic principles and good practices from other types of emergency preparedness and response are applicable and should be familiar. The following five principles are particularly important.

1

Most of the response to extreme heat events takes place at a household or community level. Humanitarian organisations should focus on ensuring that people have the information and tools that they need to help themselves and their neighbours.

Many of the most effective responses to heat are based on small changes to individual behaviour (such as keeping hydrated or refraining from physical labour during the hottest parts of the day). Humanitarian response activities should focus on supporting people in their own efforts to stay safe and healthy. Because many people are not aware of the risks of heat, community risk education should also be a key element of humanitarian activities [18].

2

Extreme heat does not affect everyone equally. Certain groups within the population are much more vulnerable than others. Activities should be designed to address the particular circumstances of population groups most vulnerable to the effects of heat.

Vulnerability to heat differs greatly across a population. Elderly people, people with pre-existing medical conditions, pregnant women, and children have particular physical vulnerabilities to heat. In addition, marginalised population groups (which often include these groups as well as disabled people, women and girls, displaced people, marginalised caste groups, migrants and LGBTQI+ people) are frequently more exposed to heat as a result of poor quality housing and lack of cooling. They may also experience barriers to accessing information and services, be at increased risk of

violence, exploitation, or neglect during heatwaves, and experience greater social isolation or dependence on caregivers (see Box 3: Vulnerability to heat). Heat preparedness and response should be specifically designed to prioritise vulnerable people. Bear in mind the specific nature of physical and social/political/economic drivers of vulnerability (for example, by recognising that some groups may require particular efforts to engage with communications and services). At the same time, the specific vulnerabilities of responders and humanitarian staff should also be considered, and their work structured to reduce the risks to them.

3

Activities should be planned and delivered in coordination with other stakeholders.

An effective plan requires expertise, knowledge and skills from a variety of different organisations. Health organisations are particularly important, as are disaster management and coordination agencies, meteorological organisations and the media [22, 9]. Organisations need to work together to provide the range of services required – they also need to provide common public messaging, using agreed terminology [9]. The importance of multi-agency coordination has been apparent in a number of Heat Action Plans from different countries [18, 23, 22]; where activities have not been executed successfully, it has often been because of poor coordination between organisations.

4

Effective response is based on effective preparedness.

An effective response to extreme heat begins months, or even years, before a heatwave occurs: specialist staff (such as WASH engineers and healthcare providers) need to be trained in the specific impacts and requirements of extreme heat, communications messages developed and agreed, and early warning systems put in place. In the (many) humanitarian contexts where the threat of extreme heat is increasing rapidly, these preparedness activities should start as soon as possible. In addition, humanitarian actors should be engaging in and advocating for Disaster Risk Reduction (DRR) activities related to heat in high-risk areas. Improvements to settlement layout, shelter design and public buildings, for example, can greatly reduce the impact of extreme heat on vulnerable people.

5

Extreme heat is a new threat for many humanitarians – and many governments. Organisations should ensure that they evaluate, learn and share learning about their responses.

Communities and governments have been responding to disasters such as floods or tropical storms for centuries, and humanitarian organisations for decades. There is a solid existing body of knowledge related to this type of response. In contrast, the first formal Heat Action Plan (from Ahmedabad in India) was only implemented in 2014. The world – and humanitarian organisations – still have much to learn in terms of the best ways to respond to extreme heat, and so it is vital that response actors learn from successes and mistakes and share their learning.

Box 2: Not just the thermometer reading

Most of us are used to thinking of temperature in terms of thermometer readings. But the thermometer only measures the air temperature – there are a number of other factors that determine how we actually feel the heat [9].

In addition to air temperature, these factors include:

- Infrared radiation (from the sun or reflected off surfaces like pavement and buildings)
- Airflow (like wind or drafts, which helps cool the body by moving warm air away)
- The heat from any surface that an individual is touching (such as a hot metal bench)
- Atmospheric humidity

Together, these elements create what is known as the 'Apparent Temperature' [53], sometimes known as the 'feels like' temperature, which dictates how the body truly responds to its environment.

For example, if the air temperature is 32 °C, a strong wind can make the apparent temperature feel lower than 32 °C, and the body will respond to that lower heat. However, if it is 32 °C with no wind and very high humidity, the apparent temperature

will feel higher than 32 °C, and the body will react as if it were hotter (at 80% humidity and 32 °C, the apparent temperature will be 44 °C).

So, when assessing the danger that heat poses to health, it is crucial to consider the apparent temperature, especially in regions with high humidity.

One way of doing this is by using the Heat Index, which measures the combined effect of air temperature and humidity (although it does not consider wind or infrared radiation, providing the apparent temperature of a location, assuming that the person in that location is in a shaded environment and out of the wind). A full Heat Index table is available in Annexe 1: Heat Index.

3 Adapting Humanitarian Activities to Respond to the Risk of Extreme Heat – Sectoral Approaches

The following section outlines the key issues that extreme heat presents for humanitarian work in the sectors of Risk Communication and Community Engagement (RCCE), Health, Water, Sanitation and Hygiene (WASH), Nutrition, Food Security and Livelihoods, Shelter and Protection.

It also suggests, for each sector, specific programmatic activities and adaptations that humanitarian organisations can take to reduce the risk to people in receipt of humanitarian assistance, and to prepare for and respond to heatwaves.

The choice of DRR/Preparedness/Response activities will depend on the specific context and funding available. It should also be informed by a Vulnerability and Capacity Assessment (see Annexe 5: Vulnerability Capacity Assessment (VCA)).

Risk Communication and Community Engagement (RCCE)

RCCE and extreme heat – *key issues*

The frequency and danger posed by heatwaves are increasing very rapidly [40, 56].

However – perhaps because of the speed of these changes – many people are unaware of the increased threat posed by heatwaves to their health and well-being [8, 58, 111].

Marginalised groups, such as women and people from lower-income sections of society, are particularly unlikely to know about the risks of extreme heat [57].

Some groups of people, while recognising that heat is a threat to their community, may not see themselves as being personally at risk. The literature provides examples of young people underestimating the risk to themselves and of older people who do not see themselves as 'elderly' and so ignore messages designed for them.

Higher levels of knowledge about the threats of heat are associated with people changing their behaviour to reduce their risk [59]. But knowledge of risks on its own does not always

translate into people changing their behaviour: there can be a 'gap between awareness and action' [58].

Effective behaviour change is more likely where knowledge about the risks of extreme heat is combined with a good understanding of practical actions that people can take to stay safe [59].

Box 3: Vulnerability to heat

The danger posed by heat differs significantly depending on several physiological and social factors. This means that certain groups are particularly vulnerable to ill health and death because of increased temperatures. Important groups to consider in the Heat Health Action Plan are:

The Elderly	Heat-related deaths occur predominantly among older people [4, 42, 43, 27, 26, 7, 15, 18, 9]. Some sources suggest that 80% of heat-related deaths occur among older people. This can largely be explained by the fact that older people 'have reduced thermoregulatory responses: sweating rate, skin blood flow and cardiovascular function...ageing is also associated with physiological changes in renal function that increase the risk of renal failures' [9]. Elderly people – in common with other vulnerable groups on this list – may also have enhanced vulnerability through economic marginalisation (resulting in poor housing and limiting options to keep cool), isolation, and reliance on caregivers and services that can be overwhelmed by extreme heat.
People with pre-existing health conditions	In heatwaves, most deaths seem to come from the worsening of existing health conditions, rather than from heatstroke [9, 15,]. A wide variety of Non-Communicable Diseases (NCDs) are associated with heat-related mortality (see Box 5: Heat and the human body). Several authorities cite cardiovascular disease as the main cause of heat-related death [3, 14], although these figures should be treated with caution [9] as they may reflect the way that data are collected and the studies designed. Heat exposure can also increase the toxicity of certain medications or decrease their efficacy, and some medications can interfere with the body's cooling responses [18, 9].

Pregnant women	Pregnancy increases women's vulnerability to heat as a result of raised body temperatures [15] and less effective thermoregulation [4, 129]. Heat stress during pregnancy can impair placental function and blood flow, increasing the risk of preterm birth, low birth weight, and small-for-gestational-age infants [78, 79, 120]. Some studies have suggested that women in general are more vulnerable to the effects of heat than men [9], but the evidence is inconclusive [119].
Children and infants	Children and infants are often cited as being at higher risk to heat than adults [4, 33, 7, 15, 18] as a result of their differing metabolism (sweating less per kilogram of body weight and having higher metabolic rates), and the fact that they are reliant on carers to regulate their environment and receive adequate fluid intake [18].
People suffering from malnourishment	People suffering from malnourishment are not widely discussed in the literature, but data from the International Medical Corps and the Ministry of Health (MOH) Mali suggest that the mortality rates of severely malnourished children are 2.75 times higher during the hottest three months of the year, when compared to the other nine months of the year.
People with disabilities	For people whose disabilities are impacted by temperature sensitivity or thermoregulation, such as multiple sclerosis or spinal cord injuries, high ambient temperatures may negatively impact their health. Further, several medications taken to address mental and physical disabilities influence thermoregulation.
People in urban areas	Urban areas are generally hotter than rural environments: materials such as concrete and asphalt store heat; population densities and the use of heat-emitting technologies tend to be higher in cities. This creates what is known as the 'Urban heat island effect' [18, 15, 9, 8] (see Box 7: What is an 'Urban Heat Island'?).
Unhoused people and people living in informal settlements	Unhoused people and people living in informal settlements are often particularly vulnerable to extreme heat as a result of the densely packed housing, poor building materials, limited vegetation, and lack of access to public services and amenities found in informal settlements or areas where unhoused people congregate [8, 9, 15]. In some cities,

	temperatures in informal settlements have been measured as being significantly higher than in other parts of the city [20].
People working outdoors	Outdoor work is an important risk factor for heat-related illness [18, 4, 20, 11].
Socially marginalised groups	Socially marginalised groups (who often overlap with the groups above) include sections of the community such as marginalised economic and caste groups, migrants, displaced people and LGBTQI+ people. They all may be at heightened risk due to poor quality housing, an inability to afford cooling mechanisms, limited access to services and information, and stigma and discrimination.

Taken from – Creating Heat / Health Action Plans. International Medical Corps, 2025

RCCE and extreme heat – *guidance and actions to take*

Risk education is an ongoing activity: people should hear messages all year, and not only when a heatwave is about to occur (although the intensity of messages should increase when a heatwave is forecast).

Heat messaging can be included as part of other humanitarian RCCE activities (e.g., messaging related to community health, nutrition or WASH programming).

- **When designing messaging:**
  - Keep messages concise and easy to recall.
  - Ground communication in existing public understanding—use tools like KAP surveys or focus groups to identify knowledge gaps and preferred media channels.
  - Collaborate with affected communities or priority groups to shape and validate messages before scaling up RCCE campaigns.
  - Include direct guidance on how to act during heatwaves as well as information on the risks of heat.
  - Disseminate messages through diverse formats - SMS, radio, posters, social media, and trusted local voices like faith leaders and health staff.
  - Align messaging across agencies to maintain consistency and avoid conflicting advice.
  - Tailor outreach to specific groups, using targeted delivery methods for populations such as older adults, children, and people whose health conditions increase their vulnerability.

- **Public messaging around extreme heat generally includes:**
  - How to keep the body cool and hydrated
  - How to keep homes cool
  - How to keep out of extreme heat if outdoors
  - How to respond to heat exhaustion and heat-related illnesses
  - Sources of heat information – where to get forecasts and early warnings of heatwaves
  - How to help others – especially community members who are particularly vulnerable (the elderly, pregnant women, infants, people with heart diseases or respiratory conditions, the elderly)
  - Where messages are being shared immediately before or during a heatwave, they should also provide information on:
    - Likely timing and duration of the heatwave
    - Locations of cooling centres and health facilities
- **Some population groups to consider for specific messaging include:**
  - **The elderly.**
  - **People with underlying health conditions** that increase their vulnerability to heat (for example, people suffering from cardiovascular diseases, respiratory conditions, and diabetes).
  - **Pregnant women.**
  - **Children** – sharing messages with children at school has been a successful way of spreading messages in the community.
  - **Caregivers.** The people they care for, such as children, people with disabilities and the elderly, are all at high risk because they may not have control over their environment and rely on caregivers. So, ensuring that caregivers are aware of the threat of heat is important.
  - **Employers** – some occupational groups may be at particularly high risk. Educating employers about these risks, as well as incentivising employers to educate their workforce, can be an effective approach to decreasing risk.
- **Some examples of public messaging materials for heat include:**
  - Americares
  - WHO Europe: Heat-health action plans: guidance – recommendations for the public during heatwaves

- WHO ‘Beat the Heat’ Infographics
- UNICEF: Protecting Children from Heat Stress

See *Guidance Note 6: Risk Communication and Community Engagement Strategies for Climate Change Adaptation in WASH Programming*, for more information on RCCE and climate change.

Box 4: Staying safe during a heatwave

Key actions that individuals can take to stay safe during a heatwave include:

Staying cool

- If possible, stay in an air-conditioned area, at least during the hottest periods of the day.
- If the temperature is below 35 °C, use a fan to keep cool. Do not use fans when the air temperature exceeds 35 °C[7], as blowing hot air at the body will heat you up [9, 133].
- Keep buildings as cool as possible:
  - Shade windows and doors to prevent sunlight from entering during the day
  - If the temperature cools down at night, open any vents or windows – particularly those that are higher in the building – to allow hot air inside the building to vent into the atmosphere
  - If the atmosphere is relatively dry, hang wet cloths near windows to cool the air through evaporation
- Wear lightweight, loose-fitting, breathable clothing.
- Take cool showers or baths, if possible. Use a cool, damp cloth to wet your skin, particularly around the wrists, neck and armpits.
- Avoid cooking: the heat from cooking will heat you and your environment.
- Eat cold or room-temperature food, rather than hot foods, and prioritise foods with a high water content.

- Avoid going into the sun during the hottest part of the day. If exposure to the sun can't be avoided, wear light coloured clothing and a hat.
- Avoid physical labour or activity, particularly during the hottest part of the day.

Staying hydrated

- Drink plenty of water or electrolyte drinks (at least 2-3 litres per day). Drink water regularly, in small sips, rather than in large amounts at a time.
- If you have to work or conduct physical activity, it may be impossible to make up for the water lost through sweat. To counteract this, drink additional water at the beginning and end of the day [48].
- Avoid sweet, alcoholic and caffeinated drinks.

Responding to heat-related illness

- Know the symptoms of heat-related illness, and the particular ones associated with infants, young children, pregnant women, elderly people and other vulnerable members of the household.
- In general, if members of the household experience nausea, dizziness, cramps, heat rashes or nosebleeds, take immediate action to cool them down (see above).
- If members of the household appear confused, very dull or unconscious, experience fainting, rapid breathing or heartbeat, take immediate action to cool them down and call for medical assistance.

For messages relevant to specific population groups, see the links above in the Section RCCE and Extreme Heat: guidance and actions to take.

Health

Box 5: Heat and the human body

The human body gains heat from its environment in three ways. Heat comes from contact with warm air (convection), from conduction (heat gained from direct contact with hot surfaces, such as sitting on a metal bench) and from radiation (infrared waves from the sun or from hot objects, such as walls or pavements).

The body loses heat through the same mechanisms – by the convection of heat into cooler air or water that is moving around the body, by conducting heat into cooler solid materials (such as a wet sheet or a block of ice) and by radiating heat from the skin to other surfaces. To do this, the body increases blood flow from the body core to the skin, moving heat to the surface of the body to allow it to be transmitted into the environment. These **cooling mechanisms only work if the environment surrounding the body is cooler than the body** [18].

The body also loses heat through the evaporation of sweat, which is produced when the body temperature increases. Unlike radiation, convection and conduction, this mechanism works even when external temperatures are higher than the body temperature. But it is strongly influenced by the amount of humidity in the air. **At high levels of humidity, sweating is much less effective at cooling the body** [18].

The process of pumping more blood from the core of the body to the skin puts increased stress on the heart, lungs and circulatory system [19], which can lead to failure of these systems. Where the body's cooling mechanisms are unable to keep the body temperature down, multiple processes in the body can lead to cell, tissue and organ damage [19]. When the body's core temperature reaches around 40 °C, **heatstroke** is likely – a condition which causes dysfunction of the central nervous system and can lead to multiple organ failure [54, 55].

Health and extreme heat – *key issues*

Extreme heat is, primarily, a health issue. It does less damage to buildings and infrastructure than hazards such as floods and tropical storms. And while extreme heat affects livelihoods, these effects are often short lived (although see Food Security and Livelihoods).

The most obvious health threats of extreme heat are **Heat Related Illnesses** (HRIs): conditions such as heat rash, heat cramps and heat oedema, and – in order of increasing

severity – heat stress, heat exhaustion, and heatstroke [60]. The most severe of these – heatstroke – occurs after an individual has progressed through the preceding stages of heat stress and exhaustion, and the body reaches a core temperature of above 40 °C [130] (although the exact temperature may differ according to individual circumstances [128]). It is a systemic disorder, marked particularly by neurological impairment, such as delirium, convulsions or coma [54, 55]. Heat stroke can lead to multiple organ failure within 48 hours of presentation [55]. If untreated, it is fatal in up to 80% of cases [55]. It can have lifelong consequences for survivors.

While HRIs may be the most obvious cause of heat-related mortality and morbidity, some sources suggest that most mortality in heatwaves comes from the effects of extreme heat in exacerbating **non-communicable diseases** (NCDs) [9, 61]. Many NCDs are linked to increased morbidity and mortality in heatwaves. This seems to be particularly the case for cardiovascular disease [14, 24, 61], which is shown in meta-analyses to be the leading cause of death [14].[8] However, 'virtually all chronic diseases present a risk of death/illness due to heat' [18]. Respiratory diseases are also associated with increased morbidity and mortality in heatwaves [14, 15, 24, 61], particularly in situations where high temperatures coincide and interact with poor air quality. Similarly, renal disorders [14, 61], diabetes [18, 62], and genitourinary disorders [18] are all affected negatively by higher temperatures.

Increased temperatures and heatwaves are also known to affect **pregnant women and the foetus**. Several factors increase the vulnerability of pregnant women, the foetus and newborns to heat. They include anatomical, physiologic/hormonal and metabolic, and socio-cultural changes during pregnancy and childbirth, which can lead to hypertensive disorders, gestational diabetes, preterm and still birth, and congenital anomalies among other things. This is because of extreme heat overwhelming thermoregulatory mechanisms in pregnant women and increased metabolic activity during pregnancy, generating more heat and endocrine dysfunction [41, 61, 63].

There are strong associations between a number of **mental health conditions** and high temperatures [14, 28, 29, 30, 61].

Increased temperatures over longer periods are also associated with increased prevalence of a range of **communicable diseases**: waterborne diseases, including cholera [31, 62, 63], and vector-borne diseases such as malaria [32, 33, 34]. The link between increased prevalence of communicable diseases and (short term) heatwaves has been less well documented [66], but there is evidence of increased hospital admissions for diarrhoea [66], and increased prevalence of campylobacter [67] associated with heatwaves, and systematic reviews have found a robust link between mean weekly temperatures and the incidence of salmonellosis and campylobacteriosis [49]. Heatwaves also change behaviour – people sleeping outside (and without nets) are at higher risk of contracting malaria [14].

Heatwaves may also decrease the efficacy of some **medications** [69]. At the same time, many commonly prescribed medications might compromise heat loss responses,

increasing the risk to patients of heat-related illnesses (although most have not been systematically studied from this perspective [14]).

Heatwaves can significantly increase consultations and admissions at health facilities and, in some cases, **health services have been overwhelmed** [4, 9].

Health and Extreme Heat – *suggested DRR, preparedness and response activities*

Considering and adapting existing health protocols to reflect heat-related changes in the prevalence or incidence of disease

As outlined above, increased temperatures affect a variety of health conditions through a range of mechanisms. As temperatures increase and periods of extreme temperature become more common, the incidence, prevalence, location and seasonality of these conditions may change. Existing health protocols (for cardiovascular and respiratory diseases, for example) should be considered in the light of these potential changes and adapted if required.

Adapting health facilities and infrastructure

Adapting health facilities and infrastructure to prepare for extreme heat is an important adaptation/DRR activity, because:

- Many of the users of health facilities – elderly people, pregnant women and people with NCDs – are extremely vulnerable to heat.
- Extreme heat puts more pressure on cold chains and makes it more difficult to ensure that medical supplies and medications are kept at optimum temperatures.

Priority activities might include:

- Designing new health facilities, or retrofitting existing facilities, with active cooling mechanisms (ideally powered by solar or other renewable energy), or passive cooling techniques.
- Enhanced measures to ensure that medicines are kept at recommended storage temperatures (including solarisation or emergency backup of refrigeration equipment) and regular maintenance of refrigeration equipment.
- Measures to ensure that supplies of clean water are assured for health facilities, recognising that, during hot seasons (and particularly heatwaves), demand for water will increase.

- Additional measures to keep water cool and, where necessary, to test and purify water for facilities – hotter temperatures favour increased pathogen activity and may decrease the efficacy of chlorine and other purification measures (see WASH section below).

In countries or locations where there are high risks of other weather hazards (such as floods or cyclones), measures to adapt to increased heat should be taken along with measures to increase the resilience of infrastructure to these other hazards.

For guidance on passive cooling of health facilities and other public buildings, see *Guidance Note 4: Passive Cooling for Public Buildings*.

See the WHO checklist for ensuring that health facilities (including water and electricity supplies) are climate resilient.

Adapting health information systems, as necessary, to capture and respond to heat-related morbidity and mortality

One reason that extreme heat has not received the attention that it requires may be a lack of information on heat-related illness and deaths. Ensuring that existing Integrated Disease Surveillance and Response Systems can identify and record heat-related morbidity and mortality strengthens future preparedness and response.

Including heat/health information in community health education

Community health workers and health volunteers can be very effective channels for messaging on heat and health. Heat/health messages can be displayed and discussed at health facilities (see Risk Communication and Community Engagement, above).

Capacity development of health professionals

Building the knowledge and skills of health professionals around heat and health is an important step in building preparedness for extreme heat. The health effects of extreme heat are often not included in pre-service or in-service training for health professionals. Humanitarian health agencies should ensure that their own staff are aware of the impacts of extreme heat on health, and the prevention, diagnosis and clinical response to extreme heat conditions. They can also potentially support health authorities to address gaps in the curriculum.

Enhanced screening for health conditions associated with heat-related mortality

As individuals with certain health conditions are at heightened risk, humanitarian agencies might consider increasing screening for conditions which are associated with increased heat-related mortality, but which patients may not be aware of. Any enhanced screening should be aligned with national health protocols, and health providers should be able to offer preventative advice and treatment to people at heightened risk.

Provision of personalised advice and preventative treatment for high-risk patients

Patients at higher risk of heat-related illness or mortality (see Box 3: Vulnerability to heat) should receive personalised advice as part of their routine care. This might include the creation of a personal heat health plan, covering actions that they can take to decrease their risk during periods of extreme heat.

Guidance on creating personal heat health plans is available from Americares.

Americares also provides further information on changes to medication (which may be necessary where medications become less effective, or compromise heat regulation). This information should be read in conjunction with the respective country's MOH essential pharmaceuticals list.

Creating and testing heatwave preparedness plans

Heatwaves put significant strains on health systems, disrupting the continuity of services to meet existing needs and making it difficult to address new and increased needs. Preparedness planning can decrease disruption. Plans should include:

- Linkages to heatwave early warning systems, or other criteria for implementing the plan (such as a government announcement of a heatwave). See Annexe 4: Developing a Heatwave Preparedness Plan and Box 6: Heat early warning systems for more information.
- Measures to ensure the safety of patients: ensuring shade and water are available, adjusting operational hours of (non-emergency) health services and potentially using mobile clinics or telemedicine options to decrease patients' exposure to heat.
- Specific measures to ensure the safety of highly vulnerable patients, such as moving inpatients to cooler areas of the building or providing fans (*only* in air temperatures of 35 °C or below).
- Measures to ensure the safety of staff: changes in uniform regulations and ensuring regular rest and hydration breaks.

- Measures to respond to increased, heat-related needs:
  - Stocks of medications and equipment
  - Trained 'surge staffing'
  - Additional bed space (for inpatient facilities)
  - Transport for referrals
  - Provision of healthcare outside health facilities (for example, at cooling centres, facilities provided for (vulnerable) people to rest and lower their body temperature)
  - Outreach mechanisms for highly vulnerable people.

These plans should be tested through simulations or table-top exercises.

Water and Sanitation (WASH)

WASH and extreme heat – *key issues*

During heatwaves, demand for water increases significantly. As an example at the individual or household level: while the recommended intake of water for a sedentary man in a temperate climate is 3L/day [70], an active adult working in a hot, humid environment can lose up to 3L/hour in sweat [48].[9] Water use also increases as people use water to keep cool. Water supplies are likely to be under increased demand from non-domestic uses.

Water quality and safety can be affected by **increased microbial growth and pathogen activity** (see Health and extreme heat – key issues – communicable diseases). This is an area where further research is required: 'most studies focus on just a few [pathogen] species, and substantial knowledge gaps remain regarding persistence, infectivity, and shifts in microbial community structure at high temperatures relative to lower water temperatures' [71]. In piped water systems, increased temperatures also change the composition of biofilms, with a potential increase in pathogens [72].

At the same time, extreme **heat affects the chemical treatment of water**. As the temperature increases, the free chlorine residual decays faster [71]. Hotter water also intensifies chemical reactions that form disinfection by-products (e.g., trihalomethanes from chlorine). Also, chemicals such as chlorine solutions and granules quickly lose their strength in heat [132]. Warmer water both reduces coagulation using aluminium sulphate or ferric chloride and the settling efficiency because floc formation is slower and less stable, leading to poorer turbidity removal [132].

Electrical **power failures** are commonly experienced during heatwaves. Where WASH infrastructure is dependent on the electricity grid, this can lead to a failure of water supply and distribution [73]. Extreme heat can also make pumps more likely to fail.

Where water pipes or storage are exposed to heat, or buried close to the surface, drinking water becomes warm and **unpalatable**.

With respect to sanitation, there has been very little research on the effects of extreme heat on sanitation systems [74]. It is possible that extreme heat **decreases the functioning of VIP latrines**, which rely on a temperature gradient between the pit and the outside environment to create the convection current to eliminate flies and smells [75]. Extreme heat in most latrines is also likely to increase odours and make the latrine structure uncomfortably hot, which may lead to decreased use.

WASH and Extreme Heat – *suggested DRR, preparedness and response activities*

Adapting WASH facilities and infrastructure

Adaptations to increase resilience to heatwaves might include:

- Measures to decrease the reliance of pumps on the electricity grid (such as solarisation).
- Measures such as shading to prevent water from becoming unpalatably hot in storage and distribution infrastructure.
- Changes to latrine structures to support passive cooling (see *Guidance Note 11: Climate Resilient Faecal Sludge Management*).

More frequent testing and chemical treatment of water

To address issues of increased potential pathogen load and decay times of chemical treatment, both testing and chlorine dosing should be more frequent.

Chlorine should also be prepared or purchased in smaller amounts (for more frequent dosing) and stored in cooler locations.

Capacity building for community water committees

Train water committees on issues related to extreme heat and water, such as the need for increased testing and treatment (above), and changing pump times to coincide with cooler parts of the day.

Preparedness planning to meet increased demands for water

Decide in advance how increased demands for water during heatwaves will be met and ensure that relevant supplies (such as purification tablets for at-home treatment) and

arrangements (such as pre-contracting for water tankers) have been sourced and prepared in advance. Ensure that arrangements do not put people obtaining water (often women and girls) at increased risk from heat or other threats.

Nutrition

Nutrition and extreme heat – *key issues*

Exposure to extreme heat is **linked to acute malnutrition, hospitalisations for undernutrition, and chronic malnutrition**.

Research on data from five countries in West Africa shows that recent exposure to 100 hours of high temperature increases the rate of **wasting** in children aged 3-36 months [76].[10] The same study showed that exposure to high heat over a child's lifetime increased the likelihood of **stunting** [76].[11]

A study in Brazil found that increased temperatures were associated with increased **hospitalisations for undernutrition** in the 0 - 7 days following the heatwave, with children between five and nineteen years, and people over eighty years, being most strongly represented [77].

Maternal exposure to extreme heat is also strongly associated with **low birth weights** [78, 79], which, in turn, is associated with childhood stunting [80].

There are a number of potential reasons for the association between extreme heat and malnutrition, and the specific combination of causes will differ from one context to another. They include:

- Limited access to nutritious food as a result of, for example, decreased productivity/ death of household livestock, or decreased household income (see Food Security and Livelihoods, below).
- Increased prevalence of diseases, particularly gastrointestinal diseases, affecting nutrient uptake and retention (see Health section above).
- Decreased appetite during extreme heat [81].
- Impaired nutrient retention and absorption, which can result in acute malnutrition [122].
- Changes to care practices. A study of 36 Low and Middle-Income countries demonstrated that heatwaves affected the dietary diversity and meal frequency of children aged from 3-23 months [81].
- Lactating women may also experience altered breastfeeding practices due to heat. While – except for cases of severe dehydration – breast milk generally remains

sufficient for hydration [123], perceptions of milk insufficiency during hot periods can lead to an early introduction of water or complementary foods, potentially compromising infant nutrition [122].

Nutrition and Extreme Heat – *suggested DRR, preparedness and response activities*

Adapting nutrition sites and other locations associated with nutrition programmes

As with health facilities (see Health and extreme heat – suggested DDR, preparedness and response activities above), nutrition sites serve populations who are highly vulnerable to extreme heat. Consider including passive cooling strategies in new buildings or retrofitting existing buildings to decrease the temperatures for building occupants and people waiting outside. Review the availability of clean water, power for refrigeration, and other vulnerable infrastructure to ensure that nutrition sites can remain operational during heatwaves. Also consider prepositioning stocks of oral rehydration salts, micronutrient powders, and ready-to-use therapeutic foods in high-risk areas.

Altering the timing of activities

To the extent possible, alter the timing of activities so that they correspond to cooler times of day.

Training of nutrition staff on nutrition and extreme heat

The training should include modules about recognising and managing heat-related illnesses in malnourished children and pregnant women, as well as training on nutrition counselling messages related to extreme heat.

Including messages related to extreme heat in Infant and Young Child Feeding (IYCF) and other nutritional counselling

Messages should include the importance of hydration for women who are breastfeeding and young children, the importance of continuing breastfeeding during heatwaves, and the importance of providing nutritious, high-water-content foods.

Distributing Multiple Micronutrient Powder (MNP)

Where the situation requires, consider distributing MNP and providing community sensitisation on MNP use through existing IYCF programmes.

Box 6: Heat early warning systems

Response plans for heatwaves are most effective when they are linked to a heat early warning system. Two or three days of early warning will allow people and organisations to take preparatory action (e.g., setting up and publicising cooling centres, changing facility opening times and notifying users, bringing in surge staff for health facilities) so that the response can take place as soon as the heatwave begins.

Establishing Early Warning Systems (EWS), including the criteria and thresholds that are used to declare a heatwave, are highly specialised activities and beyond the scope of this guidance (for some of the issues involved, see Box 1: Defining a heatwave). Guidance – currently being updated – is available from WMO/WHO [9].

Humanitarian agencies should use the early warning system used by national authorities wherever these exist. Where national authorities (and in particular the MOH/meteorological office) have not established early warning systems, and where there is a risk of extreme heat, humanitarian agencies should encourage them to do so.

In some cases, countries use EWS developed by regional organisations in collaboration with national meteorological offices from across the region (although not all government agencies will necessarily be aware of them). If no national or regional heat EWS exists, humanitarian agencies may consider using global-level heat forecasts, in coordination with government, where possible. See Annexe 3: Regional and Global Heat Early Warning Information.

Note that these various regional and global EWS use different ways of measuring heat stress and so are not always comparable.

Whichever system is used, it is important that:

- All agencies involved in the response use the same EWS to support coordinated work and avoid confusing the general public.
- There is a clear system for communicating warnings to each operational organisation, and each organisation has a focal point responsible for receiving and disseminating messages.
- There is also a system for communicating warnings to the general public, with particular attention paid to ensuring that vulnerable groups are informed.

You have decided when each main activity commences: on receipt of the warning? One day before the heatwave is forecast to begin? On the day the heatwave begins? (This is, ideally, as part of a multi-agency plan – see Annexe 4: Developing a Heatwave Preparedness Plan).

You have decided what the criteria are for determining that the heatwave has ended, and how this will be communicated. (Again, ideally this is a multi-agency decision).

Where no formal EWS exists and practitioners are dependent on using weather forecasts in place of an early warning system, decide:

Who in the organisation is responsible for monitoring forecasts

When they should be monitored (Daily? Weekly? All year? Only in the hot season?)

Food Security and Livelihoods (FSL)

FSL and extreme heat – *key issues*

Crop production

It is important to **differentiate between heatwaves and drought** as they have different effects on crop production. Heatwaves may occur during droughts, and they can contribute to drought by increasing the evaporation of moisture from the soil. But heatwaves also have separate, specific effects on crop production.

The impact of heatwaves **depends on the period in the growing season** when the heatwave occurs and its scale and duration. Staple crops are most susceptible to heat damage during their reproductive period. Heat interferes with processes such as the production of pollen, growth of pollen tubes and early filling of the grain [84]. Heatwaves occurring during this growth period are likely to greatly decrease yields.

Different crops show different degrees of heat tolerance, but even crops that are generally heat tolerant can be very vulnerable during the reproductive period. Trials suggest that during this period, high degrees of loss occur:

- In wheat – from short periods (one day) of heat above 31 °C [82]
- In maize – periods of more than three days at 35 °C and above [85]

- In rice – from very short periods (as little as one hour) at 35 °C and above [83]
- In millet – short periods (two days) of heat above 38 °C [86]. Millet plants do, however, have several successive reproductive periods, so if one fails, fertilisation may take place at the next one
- In sorghum – short periods of heat above 36 °C [87]

Livestock production

Heatwaves have similar effects on livestock as on humans. In situations of high heat/humidity, animals' heat loss mechanisms are less effective, and this leads to **increased illness and mortality**. It also leads to **decreased productivity**.

As well as physiological responses (such as increased heart rates, vasodilation and panting), animals also exhibit behavioural responses to heat, such as seeking shade and decreased feeding.

In **cattle**, high temperatures lead to decreased milk production, negative *in utero* effects (which may lead to low birthweight or stillborn calves) and a depressed immune system (leading to an increased vulnerability to disease [88]). *Bos Indicus* are more heat tolerant than *Bos Taurus*, in some studies showing physiological signs of heat stress only at temperatures over 40 °C [89]. In the same study, *Bos Taurus* species showed signs of heat stress at 32 °C, although other work suggests that heat stress might be experienced above 25 °C [91]. Humidity, as well as temperature, is an important determinant of heat stress in cattle and other animals [90].

Small ruminants, and particularly goats, are generally considered to be better adapted to heat stress than cattle [92], although they experience the same problems when heat stressed [93]. Many tropical breeds of sheep are comfortable to 30 °C and can withstand temperatures to 38 °C without serious adverse effects [92], although this is also humidity dependent [93].

Pigs are very susceptible to heat stress because of their thick layer of subcutaneous fat. As they are less able to thermoregulate in higher temperatures, they are dependent on behavioural adaptations, such as seeking shade and wallowing in mud or water to manage heat [94].

Labour

Manual workers, particularly those working outdoors in jobs such as agriculture or construction, are consistently noted as being highly vulnerable to heat stress [95]. During heavy manual work, metabolic heat production can increase by a factor of 15 [14], greatly increasing the impact of extreme heat.

While manual workers are particularly vulnerable, **many other groups of workers are also at risk**, including indoor workers in poorly regulated sectors, and groups working outdoors, such as market traders and bus conductors [96].

In addition to the potential health impacts of heatwaves, research in India has shown that heatwaves decrease the amount of time informal sector workers are able to work during a day by 1-2 hours and decrease the productivity of work – **decreasing their income** [97, see also 117, 143, 144]. At the same time, the impact of extreme heat on agriculture may impact **food prices** [121]. The health impact of heatwaves can also lead to increased medical expenses. The impacts of heatwaves on incomes are likely to be larger for female headed and poorer households [98].

FSL and Extreme Heat – *suggested DRR, preparedness and response activities*

For Agriculture

Support crop diversification

A possible response to increased heat threats is to grow a broader range of crops, particularly if this includes a larger proportion of heat tolerant crops. Crops should also be tolerant of other potential climate threats, and suitable for growing in the area: this can be explored with the Ministry of Agriculture or similar bodies where these exist.

Adjusting planting times

Adjusting planting times can help ensure that the reproductive period does not coincide with potential heatwaves. Again, any adjustments should take the broad range of factors involved in successful cultivation into account and avoid creating vulnerabilities at other periods of the agricultural cycle.

Shading crops

In some places, it may be possible to provide shade to crops by intercropping with taller varieties or using agroforestry techniques. Both approaches reduce air temperature through the evapotranspiration of the additional plants. Shade netting, along with intercropping and agroforestry, will also decrease solar radiation on growing crops.

Interventions at harvest

Where yields have been significantly decreased as a result of extreme heat earlier in the growing season, cash interventions and/or provision of seeds may support livelihoods.

For Animal Husbandry

Supporting the provision of shade and water

Increasing the amount of shade and water available to livestock, particularly where these are scarce, is a useful intervention. Animals can double the amount that they drink during heatwaves.

Providing nutritional support

Nutritional adjustments, such as high-energy feeds and electrolyte supplements, can help to maintain animal health. These may not be readily available to communities, and humanitarian actors can support by sourcing, providing and advising on the use of feeds and supplements.

Providing advice on management practices

Where communities do not have extensive experience of extreme temperatures, advice may be useful on areas such as: ventilation/passive cooling (where animals are kept indoors), minimising handling of livestock during hot periods, and adjusting feeding times.

Cash interventions

Where extreme heat has led to losses of animals, particularly for the poorest households who are likely to be heavily reliant on these animals for nutrition and income, humanitarian agencies can consider cash interventions or restocking. If restocking, the heat tolerance of the replacement animals should be a selection criterion.

For Wage earners

Identifying ‘at-risk’ groups

Although outdoor labourers will almost always be at a high risk of heat exposure, other occupational groups may also be vulnerable. Humanitarian organisations should identify these groups in advance and develop specific support strategies for them.

Ensuring that RCCE messages on heat reach at-risk groups – and employers

Wage earners, particularly when they are younger, may be unaware of the dangers of exertional heat stress. RCCE messages should be targeted specifically at this group, including messages around: hydration (including hydration before and after working periods), taking rests, and altering working hours. Where possible, humanitarian agencies should also engage with formal and informal sector employers to educate them on the dangers of heat at work.

Ensuring the safety and occupational health of humanitarian employees

Humanitarian agencies should ensure that they have contingency plans in place to safeguard the health of their own employees during heatwaves, including cool areas, hydration, adjusted working hours and rest breaks.

Providing water, shade, electrolytes

Provide water, shaded areas (see also the section on cooling centres, below) and electrolytes in areas where at-risk groups are working.

Cash Interventions/Social Safety Nets

Humanitarian agencies can also consider targeted cash interventions to replace lost wages. Where shock-responsive social safety nets exist, there may be the potential to integrate these into heatwave responses.

Shelter and Settlement

Shelter, settlement and extreme heat – *key issues*

As there is fairly limited information available on the impact of extreme heat on populations requiring humanitarian shelter [107, 109] [12]*, some of this information relates to informal settlements.*

Many displaced and refugee populations live in areas that are at high risk of heatwaves [108, 109].

People living in informal settlements are generally more exposed and vulnerable to extreme heat than other populations and are more likely to suffer when heatwaves occur [104, 105, 106, 118].

This is partly because of the layout of such settlements, which are often densely populated with limited vegetation cover (see Box 7: What is an 'Urban Heat Island'?). Informal neighbourhoods can be 1 to 4 °C hotter than adjacent formal neighbourhoods [109].

Introducing vegetation, particularly trees, to the built environment decreases air temperatures in the surrounding areas: temperature reductions of around 5 °C have been observed in several studies [114], with reductions of 9 °C in some [116]. The hotter and more arid the environment, the more effective trees become at cooling it [114]. The type, density and height of trees have a significant influence on their cooling effect [115].

The increased vulnerability of people to heat in informal settlements is also a result of shelters which are not designed to minimise heat and which use materials with high thermal conductivity (such as corrugated sheet metal). In one case in South Africa, the air temperature in sheet metal shelters was 17 °C hotter than the external temperature [111].

High internal temperatures can also be a challenge in temporary/transitional humanitarian shelters, which are generally designed to be lightweight and low cost [112]. Internal air

temperatures in shelters in humanitarian contexts have been measured at over 40 °C centigrade in several locations [112]. IDPs in Sri Lanka [110] and refugees in Iraq [112] have been shown to be at a dangerous risk of heat illness when inside shelters.

Improvements to temporary shelters, such as ventilation, insulation and shading, have been shown in models to significantly reduce indoor temperatures [112, 113].

Box 7: What is an 'Urban Heat Island'?

The term 'Urban Heat Island' (UHI) effect describes the fact that urban areas are generally hotter than the rural areas that surround them [99, 100].

There are several reasons for this. The main one is that, in cities, vegetation is replaced by solid surfaces such as tarmac and cement. Vegetation generally cools the environment – through evapotranspiration (which cools the air in a similar way to sweating), and through the provision of shade. Solid surfaces, on the other hand, generally heat the environment, as they absorb heat more readily and then radiate it out [99, 100]. Therefore, replacing vegetation with solid surfaces increases the temperature of urban areas.

In addition, cities are hotter because of the intensity of mechanical activities: the burning of fuel by vehicles, heat produced from industrial processes, and waste heat ejected by building ventilation and air conditioning systems [101].

Finally – although less important in most humanitarian contexts – 'high rise' cities, with many tall buildings, can amplify UHI, because there is more built surface area to trap heat, and less exposure to the cooler night sky to allow this heat to dissipate into the atmosphere [100, 101].

Differences in temperature between the city and its rural surroundings can be significant: one review of data for 100 cities in East Asia found that they were, on average, 1.6–2.0 °C hotter than their immediate rural surroundings; some cities were up to 7 °C hotter [100]. Heat island effects of 7-8 °C have also been recorded elsewhere [101]. The effect is often pronounced at night, when buildings and other surfaces radiate out the heat they have trapped during the day [100, 101].

The UHI effect is generally more intense in cities with larger populations and/or more humid climates [103]. The effect varies across the city and is often more intense in poorer areas and informal settlements, which may have higher population densities and less shade and vegetation than other areas [100, 105, 109].

Shelter, settlement and extreme heat – *suggested DRR, preparedness and response activities*

Including trees and other vegetation in a site layout

Trees provide shade and decrease the air temperature through evapotranspiration. When including trees in a site layout, check their suitability for the area and growth habit (being aware of their potential height and effect on nearby structures and – potentially – the water table). Consider further risks when planting trees in areas exposed to other weather hazards (such as tropical storms, wildfires).

Incorporating shaded areas into a site layout

Create shade through the use of trees or (temporary or permanent) structures in areas where people may be waiting for some time, such as water sources or clinics.

Incorporating cooling elements into public buildings

Buildings such as schools, clinics and other community assets should be designed with heat in mind. Where electricity supplies are sustainable and resilient, this may involve the installation of active cooling (air conditioning or similar). It may also involve incorporating passive cooling elements into new buildings or retrofitting existing buildings to decrease internal temperatures.

For more information on passive cooling of public buildings, see *Guidance Note 4: Passive Cooling for Public Buildings*.

Adjusting shelters or shelter materials to address heat risks

Where shelters or shelter materials are being distributed by a humanitarian agency in areas at risk of extreme heat, the design and materials used should be selected to minimise internal heat, while meeting other design parameters (e.g., cost, weight, thermal efficiency in cold periods). In many cases, local communities will have identified effective approaches and designs for cooling buildings – humanitarians should engage with communities to identify and support these approaches.

Incorporating information on passive cooling techniques and materials into self-build programmes

Where agencies are supporting communities to build their own shelters, they should encourage community members to share local knowledge on cooling techniques and provide additional information on techniques and materials that will be effective in that context. Agencies may also need to provide materials that are not available in local markets to support the incorporation of passive cooling elements.

Establishing cooling centres

Cooling centres are facilities established during heatwaves to give people – and especially people who are particularly vulnerable to heat – a place to rest and lower their body temperature. In environments where electricity is available, they are generally air conditioned, as this is the most effective way of cooling the body down.

Where air conditioning is not available, cooling centres can be in any structure that is cooler than the external environment. These may be community buildings built using passive cooling techniques– as is often the case with traditional buildings in hot areas – or even shaded temporary structures in green spaces. These facilities are particularly important where people are working outside in the heat, or where people live in temporary structures which have high internal temperatures.

When determining what facilities to use as cooling centres, or where to place temporary cooling centres:

- Think about who is vulnerable, and who will use the centres, and ensure that the proposed centres are close to where they will be needed.
- Ensure that the facility will be as cool as possible:
  - If using an established building, such as a community hall or religious building, ensure that it is designed to remain (relatively) cool during hot periods.
  - Do not use schools as cooling centres during the school term.
  - If planning a temporary shelter, locate it in a shaded area, and ideally one with greenery. Avoid placing on asphalt or concrete.
  - If designing a temporary shelter, place it on an east/west axis, to avoid having a long wall exposed to the sun all day.

More detailed guidance on the location of cooling centres is available from the IFRC's City Heat Wave Guide.

Clarity about the criteria for opening – and closing – cooling centres is also important (based on a heat early warning system, or government announcement of a heatwave, or

another criterion?). See Annexe 4: Developing a Heatwave Preparedness Plan and Box 6: Heat early warning systems.

For cooling centre amenities and services:

- Ensure a minimum of 2 m^2 of space per person.
- Ensure an adequate supply of clean drinking water.
- Ensure that basic amenities, such as toilets, are available or accessible.
- Ensure that shelters are accessible to people with limited mobility.
- Consider making safe storage facilities available.
- Consider separate facilities for men and women and take measures to ensure the safety of women and girls using the shelter.
- Make information on heat and health available in the cooling centre; personnel should train users in basic heat precautions.
- Make transport available to transfer people exhibiting signs of heat stress to a medical facility.

Cooling centres should be staffed by trained personnel with first aid training and an understanding of the health implications of heat.

On arrival at the cooling centre, users should be screened for signs of heat stress and appropriate action taken.

See the Installation and Management of Community Cooling Centres by the German Red Cross for further guidance.

Protection

Protection and Extreme Heat – *key Issues*

As noted above (see the Section: Five Principles for Humanitarian Organisations Addressing Extreme Heat and Box 3: Vulnerability to heat), heatwaves do not affect everyone equally. Extreme heat disproportionately affects the most marginalised populations in a society: the physiological, economic, social and political factors that lead to marginalisation also make these people more vulnerable to heatwaves [2, 4, 15, 23].

For example, disabled and elderly people, in addition to physiological vulnerabilities to heat, may not have access to communications channels carrying heat-related messages, may have limited mobility that makes it harder for them to access shelters, and may be

extremely reliant on caregivers, whose own capacity may be reduced during extreme heat [135, 136, 137].

Similarly, women and girls can be at additional risk during heatwaves because of gender norms and social expectations related to their roles in the household (cooking and fetching water can expose women to additional heat). In contexts where women face restrictions on their movements or presence in mixed settings, these restrictions can prevent them from seeking cooler environments, reporting risks, or accessing services.

A key protection issue associated with extreme heat is the relationship between extreme heat and violence. Many studies have shown clear associations between higher temperatures, crime and violence [138]. Studies have found statistically significant associations between temperature increases and murder, sexual crimes, and intimate partner violence [138, 139].

The causes of these associations are complex. Increased violence may be partially a result of the physiological impact of heat causing increased aggression (the 'temperature-aggression hypothesis' [140]) and partially a result of changes in social behaviour during heatwaves, such as people spending longer periods in confined spaces together [141]. In addition, strains on household resources and disruptions in services and community support may contribute to intra-household violence. Multiple factors are involved, and these will differ with context [138].

Extreme heat has also been associated with other protection issues, such as the risk of underage marriage. Heat waves are also associated with marriages to poorer and less educated husbands. The underlying relationship between heat and underage marriage is unclear [142].

Protection and Extreme Heat – *suggested DRR, preparedness and response activities*

A recognition of the specific protection issues associated with heatwaves, and the ways in which they affect different sections of the population, is required across the response, and should be incorporated into sectoral programming. A number of these issues have been included in the sectoral sections above.

In addition, protection actors may consider:

Raising awareness of the increased risks of violence and abuse associated with heatwaves

Ensuring that community groups, service providers and healthcare workers are aware of the links between extreme heat and violence and are collaborating with healthcare and other service provision organisations to include relevant messages in training and capacity building work.

Including messages relating to violence and abuse as part of heat-related RCCE campaigns

Working with women-led organisations, disability groups and groups representing other marginalised sectors of the population to develop and communicate messages about protection-related risks of heatwaves and actions that people can take, as part of a broader heatwave RCCE campaign.

Providing information on extreme heat in women and child-friendly spaces

Women and child-friendly spaces can be important venues for displaying and discussing information on the risks associated with extreme heat, and on actions that people can take to stay safe during heatwaves.

Adapting women and child-friendly spaces

Consider including passive cooling strategies in new buildings or retrofitting existing buildings to decrease the temperatures for building occupants. Review the availability of clean water, power for refrigeration, and other vulnerable infrastructure to ensure that women and child-friendly spaces can remain operational and safe during heatwaves.

Creating and testing heatwave preparedness plans for reporting and referral services

Reporting and referral services associated with protection programming should decide and communicate in advance:

- How they will ensure that they have the capacity to respond to potential increases in intra-household violence, Gender-Based Violence, and other protection issues associated with heatwaves.
- Changes in the timing of services to prevent service users and staff from being exposed to extreme heat at the hottest part of the day.
- Actions that they will take to ensure the well-being of staff during heatwaves.
- Establishing or expanding outreach to housebound individuals or those with particular vulnerabilities.
- Criteria for implementing the plan (based on an early warning system, or government announcement of a heatwave, or other criteria?). See Annexe 4: Developing a Heatwave Preparedness Plan and Box 6: Heat early warning systems.

Ensuring that cooling centres are accessible and inclusive for marginalised groups

The location and design of cooling centres should take the specific challenges and needs of women, people with disabilities, older people and other marginalised groups into account. Representatives of these groups should be consulted about the design of cooling centres, and agencies running cooling centres should ensure that they are safe spaces for all sections of the community.

Ensuring that complaint and feedback systems remain accessible during heatwaves

Consider how restrictions on movement and other changes related to extreme heat might affect people's ability to use complaint and feedback mechanisms; adapt these systems to take this into account.

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Annexe 1: Heat Index

The table below outlines the Heat Index. The Heat Index is a way of describing the 'apparent temperature' – how the body feels at a given temperature and level of humidity. In humid environments, this is particularly important – as the table shows, in an environment where the humidity is 80% and the air temperature is 34 °C, the body will experience a temperature of 52 °C.

Figure 1: Temperature/Humidity Index.

Relative Humidity %	Temperature °C																
	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
40	27	28	29	30	31	32	34	35	37	39	41	43	46	48	51	54	57
45	27	28	29	30	32	33	35	37	39	41	43	46	49	51	54	57	
50	27	28	30	31	33	35	36	38	41	43	46	49	52	55	58		
55	28	29	30	32	34	36	38	40	43	46	48	52	54	58			
60	28	29	31	33	35	37	40	42	45	48	51	55	59				
65	28	30	32	34	36	39	41	44	48	51	55	59					
70	29	31	33	35	38	40	43	47	50	54	58						
75	29	31	34	36	39	42	46	49	53	58							
80	30	32	35	38	41	44	48	52	57								
85	30	33	36	39	43	47	51	55									
90	31	34	37	41	45	49	54										
95	31	35	38	42	47	51	57										
100	32	36	40	44	49	56											

Caution | Extreme Caution | Danger | Extreme Danger

Annexe 2: Understanding Heat Risks in a Particular Country or Area Within a Country

The risk of heatwaves differs from one country to another, and from one area of a country to another. There are a number of resources available that can help provide an idea of how high the risk of a heatwave is in any particular area.

The primary sources for information regarding heat risk within a country are typically the **National Meteorological Agency** and/or the **National Disaster Management Agency (NDMA)**. These organisations should also have information regarding heat Early Warning Systems (EWS). Country-level risk information is also frequently available in government documents, particularly in National Adaptation Plans (NAPs).

Unfortunately, many countries where humanitarians work, and where there is a significant risk of heatwaves, are not yet fully aware of, or engaged with, the risk. In these countries, government information may be limited.

If this is the case, you can use a variety of **online tools** to gain a clearer understanding of extreme heat risks. In particular:

- **The ThinkHazard web tool**
  This tool classifies heat risk (among other hazards, like flooding) for countries and their sub-regions. It provides information for all countries, though it is not very detailed.
- **The Global Resilience Index (GRI) Risk Viewer Tool**
  This tool has an 'extreme heat' setting on its 'Hazard' page, and provides mapped information for all countries and specific parts of countries, displaying (using pixels) the % probability of extreme heat occurring in an area within a given year – currently, in the year 2030, and in the years 2050 and 2080 (using a variety of climate change projections).

It is crucial to note that these tools offer projections. Estimating climate change and its specific effects on any given area through models is an extremely difficult task. While the tools provide useful information to support decisions, especially concerning relative risk between different areas, they cannot be considered 100% accurate.

Furthermore, the GRI Risk Viewer specifically does not factor in the 'urban heat island' effect. Consequently, the future risk for urban areas is likely higher than the tool indicates[18].

In addition to these online tools, the following are links to **collections of documents** that often include information on heat risk – but note that documents are not available for all countries:

- World Bank Climate and Health Vulnerability Assessment

- World Bank Climate Risk Country Profile
- World Bank Country Climate and Development Report
- Red Cross / Crescent Climate Centre Climate Change Impact on Health and Livelihoods

See also *Guidance Note 7: Climate Data for WASH Programming* for more on where to find information around heat risk.

Annexe 3: Regional and Global Heat Early Warning Information

For East Africa / Horn of Africa (IGAD region), ICPAC produces forecasts of heat stress one week in advance. These are available at: https://www.icpac.net/weekly-forecast/ and you can sign up to receive updates here: https://www.icpac.net/subscribe/

For Africa, ACMAD produces forecasts of extreme heat one week in advance, which are available online as part of their 'Multi Hazard outlook', available at https://acmad.org/index.php/bulletins/.

The multi hazard outlook uses the threshold of 45 °C apparent temperature (a measure of heat and humidity combined) over two days as the threshold for severe heatwaves.

Globally, ECMWF produces forecasts of the Heat Index (a measure of heat and humidity combined) globally and for specific regions (using the drop-down menu) here: https://charts.ecmwf.int/products/medium-thermofeel?base_time=202505120000&layer_name=hi&player_dimension=layer_name&projection=opencharts_global&valid_time=202505120900.

The forecasts are for a week in advance, but are given on an hourly basis, so the user needs to use a 'slider' on the website to see how temperatures will evolve over the week, and how long high temperatures will last.

The 'danger' level for ECMWF is a heat index of 39.4 °C, and the 'extreme danger' a heat index of 51 °C. These are based on experience in the USA. As thresholds to use for launching a preparedness plan, the 'danger' level is probably too low, as in some cases it would lead to the plan being triggered at least once a year.[13] However, if an area is forecast to remain constantly in the 'danger' area for 72 hours (you can check this using the slider on the website) you can consider using it as a threshold. The extreme danger level, on the other hand, is very high. If an area is forecast to be in extreme danger for any period of time, this is sufficient to launch the plan.

See also *Guidance Note 7: Climate Data for WASH Programming* for where to find more information on heat early warning.

Annexe 4: Developing a Heatwave Preparedness Plan

As extreme heat is an emerging risk, many humanitarian contexts lack heatwave preparedness plans. Preparedness plans are, however, becoming increasingly common outside humanitarian contexts, and have been demonstrated to decrease mortality and disease morbidity [124, 125] – although more research and evaluation need to be done in this area.

Humanitarian organisations can use the following broad steps as an outline for developing a heatwave preparedness plan.

1. **Consider the level of risk**. While the incidence of heatwaves is increasing in many areas of the world, the risk in some areas is already very high, and is increasing extremely quickly. Where resources are limited, these areas at highest risk should be prioritised.
2. **Decide on the geographical scope of the plan.** Heatwave preparedness plans can vary in geographical scope – they can cover a single refugee or displaced settlement, a city, a larger administrative area, or the whole country. Determine the area and population to be covered by the plan.
3. **Identify and engage key stakeholders.** Effective heatwave preparedness plans are always multi-agency and multi sectoral (see Section Five Principles for Humanitarian Organisations Addressing Extreme Heat. Wherever possible, they should be led by the relevant agency or local or national government. Before beginning the planning process, determine who has overall responsibility and who needs to be involved, and ensure that key stakeholders are willing to participate.
4. **Conduct a Vulnerability and Capacity Assessment (VCA).** The VCA is the foundation of the preparedness plan. Some suggested VCA questions are provided below (see Annexe 5: Vulnerability Capacity Assessment (VCA)). Different organisations may take responsibility for conducting different elements of the VCA, according to their specialist expertise. Note the importance of considering the specific vulnerabilities of different population groups as part of the VCA (see Section Five Principles for Humanitarian Organisations Addressing Extreme Heat).
5. **If possible, identify the Early Warning System that will be used to provide warning of a heatwave.** The preparedness plan is more likely to be effective where it is linked to a heat early warning system, allowing for a more timely response. This may also require decisions on the definition of 'heatwave' in the specific context (see Box 1: Defining a heatwave and Box 6: Heat early warning systems).
6. **Identify the key activities to include in the Heatwave Preparedness Plan.** While the plan is likely to focus on key response activities that take place during the heatwave, it should also consider any DRR or preparedness activities that must be undertaken

in advance of a heatwave to enable these response activities to work. These might include activities such as training for staff who will be involved in the response or, for example, developing Risk Communication and Community Engagement messages that will be used prior to the hot season. This longer term planning is fundamental to the success of a heatwave preparedness plan and should take place well before any heatwave is expected.

7. **Clarify management and communication arrangements between key stakeholders.** Consider questions such as how will early warnings be communicated? What will be the coordination mechanism (who will be involved, will there be multiple levels of coordination, where, when, and how often will meetings take place)? How will organisations communicate with one another during the response?

8. **'Stress test' the plan.** During heatwaves, essential services, utilities and logistics may be severely disrupted. Key workers may be unable to work. Demand for electricity and water is likely to significantly increase, and electricity may fail, with knock-on effects on other services (such as telecoms, water pumping and transport). In some circumstances, road and rail services may be disrupted by the effects of heat on road surfaces and rails. Heatwaves may also occur at times of the year when other hazards (such as flooding or tropical storms) are also likely to occur. Consider the response activities in the light of these risks and adapt as required.

9. **Decide how you will evaluate the effectiveness of the plan.** Heatwave preparedness and response are rapidly developing areas, and it is important to learn from every activation. Consider how you will evaluate the plan. Will you measure the *overall results of the whole plan* (for example, decreased mortality resulting from the plan?) and/or the *intermediate results of parts of the plan* (for example, do people say that they changed their behaviour as a result of RCCE messages?) *and/or the process of the plan* (for example – did the various actors perform activities according to the plan? Were there any difficulties or problems in performing these activities?) Depending on what you want to know, what indicators will you use, and how will you get the information? It is important to decide this as part of the design of the plan, so that you can collect relevant 'baseline' data and put mechanisms in place to collect the information you will need for the evaluation.

10. **Review and test the plan.** The heatwave plan may not be needed for several years: to ensure that it is ready to go when needed, it is important to review and (ideally) test it – preferably on an annual basis. At its simplest, this involves key actors meeting to go through the plan, reacquainting themselves with their responsibilities, and ensuring that they have the resources they need to carry out the activities in the plan. With a bit more time and planning, key actors can also conduct a table-top exercise, or even a real-time simulation, to test the plan and ensure that all the elements work.

Annexe 5: Vulnerability Capacity Assessment (VCA)

Specific areas to consider for a VCA are:

- What is the area/population that this VCA covers?
- What is the experience of heatwaves in the area?
  - Have there been previous heatwaves?
  - What were the effects of those heatwaves?
  - What was the government/humanitarian response?
- What are the future risks of extreme heat in the area? Based on previous experience and climate projections, what are the:
  - Possible temperatures?
  - Possible durations of heatwaves?
  - Possible seasonality of heatwaves?
  - Potential for heatwaves to occur at the same time as other hazards (e.g., flooding, tropical storms)?
- Do the government or other agencies have extreme heat plans in place?
- Are there **coordination mechanisms** for emergency response to extreme heat (these may be existing Disaster Risk Management/emergency coordination mechanisms)?
  - Under the coordination mechanism, who is responsible for what?
  - How is information communicated between actors before heat events?
  - Has the coordination system been used in the past, and, if so, what worked and what didn't?
- Is there a heat **early warning system** in place?
  - What is the definition used for a heatwave?
  - How far in advance are warnings given?
  - Who receives these warnings?
  - Has the early warning system been used in the past, and, if so, what worked and what didn't?
- To what degree is the population aware of the potential for extreme heat, the effects of extreme heat, and the actions to take?

- Are there existing, agreed-upon public **communication** messages related to extreme heat? If so, are they relevant to specific, vulnerable sub-groups of the population?
- What mechanisms or media are available to communicate messages to the public and to engage the public around threats from heat?
- Which information mechanisms or media are particularly trusted by the public?
- Do the public receive information from early warning systems?
- What are the potential effects of extreme heat on **health**? Consider:
  - Heat-Related Illnesses
  - Effects on non-communicable diseases
  - Effects on communicable diseases
  - Sexual and Reproductive Health
  - Mental health
  - Pre-existing prevalence rates of the above
- Are any groups in the population particularly vulnerable to the health effects of heat?
- Are guidance and preventative actions related to heat included in routine primary healthcare?
- Do working health surveillance systems exist?
  - If so, do they detect and record changes in health status caused by extreme heat?
- Do public communications include key health messages? Does health education include messages on heat?
- Are health staff aware of and trained in issues related to extreme heat?
  - If not, are there opportunities for pre-service/in-service training?
- Are health facilities, storage facilities and cold chains prepared for extreme heat?
- Do health services have plans for maintaining services and addressing increased needs during periods of extreme heat?
- What are the potential effects of extreme heat on **WASH** services? Consider:
  - Demand for water
  - Water treatment and quality
  - Water infrastructure
  - Sanitation infrastructure
- Are any groups in the population particularly vulnerable?

- Is the WASH infrastructure prepared for extreme heat?
- How does the population access water for domestic consumption?
  - Are arrangements in place for increased demand?
- How is water tested and treated?
  - Are arrangements in place for increased testing and treatment?
- Are WASH committees (where these exist) aware of and trained in issues related to extreme heat?
  - If not, are there opportunities for training and awareness building?
- What are the potential effects of extreme heat on **nutrition and nutrition services**? Consider:
  - Availability/access to food
  - Food intake
  - Care practices
  - Disease risk
  - Current rates of malnutrition
  - Functioning of nutrition services
- Are any groups in the population particularly vulnerable?
- Do public communications around nutrition/nutrition services include messages related to heat?
- Do surveillance systems exist to detect changes in nutrition status caused by extreme heat?
- Are nutrition staff aware of and trained in issues related to extreme heat?
- Are there plans in place to adjust nutrition services to ensure safe operation during heatwaves?
- Are there plans in place to respond to increased malnutrition related to heat?
- What are the potential effects of extreme heat on **Food Security and Livelihoods**? Consider (where relevant):
  - Income generating activities
  - Markets
  - Crop and livestock production
  - Fishing/foraging/wild foods
- Are local production systems adapted to the risks of extreme heat?

- Are any groups in the population particularly vulnerable?
- Are agricultural extension staff/employers/representatives of workers aware of and trained in issues related to extreme heat?
- Are there plans in place to respond to increased heat stress among workers?
- Are there plans to respond to increased heat stress on livestock /losses of crops or livestock?
- What are the potential effects of extreme heat on **shelter and settlement**?
- Are any groups in the population particularly vulnerable?
- Are settlements designed to take extreme heat into account?
- Are shelters designed to take extreme heat into account?
- Are cooling centres or other facilities available for particularly vulnerable populations?
- What are the potential effects of heat on **protection** concerns (particularly intra-household violence, neglect, negative coping strategies)
- What are the potential effects of heat on protection activities?
- What are the potential effects of extreme heat on **key infrastructure and services**? Consider particularly:
  - Electricity
  - Transport
  - Telecommunications
  - Markets
- What might be the 'knock on' or cascading effects of this on other sectors?

End notes

1 A note on terminology: 'extreme heat' refers to the phenomenon of unusually high temperatures, irrespective of the period for which these temperatures last or whether the temperature reaches a specific level. The term 'heatwave' is more specific – it refers to a period when the temperature stays above a certain (locally defined) level for a specific amount of time (see Box 1: Defining a heatwave). In general, this guidance uses the term 'extreme heat', as this is an increasing challenge for humanitarian actors and the populations they serve, whether or not a heatwave is officially declared.

2 It is hoped that other key sectors, such as education, can be addressed in the near future.

3 Excess mortality of 33%

4 Estimated as 588,000 deaths/year over the same period [227].

5 The IPCC report says that this will occur when average temperatures reach 1.5 °C above the historical average – which is forecast to occur by 2035.

6 There is some debate about what these limits are – and some research suggests that more places may be closer to the limit than has previously been thought [128].

7 There is some debate as to the upper temperature at which fans are safe to use. For example, Jay et al. suggest an upper temperature of 39 °C for younger adults, and 38 °C for older adults. Given the debate around this, we have used the lower figures here as a precaution.

8 Although this may include deaths associated with heatstroke.

9 It is not possible to make up this amount of water immediately by rehydrating – and so a certain degree of dehydration is inevitable. People working in hot climates are advised to drink water before and after work, to keep fluid levels as high as possible.

10 Specifically, one hundred hours of mean monthly exposure to 30 - 35 °C heat during the previous 90 days increases the wasting rate by 2.2 percentage points. Note that the temperatures that cause wasting are lower than those which would typically be associated with a heatwave, although the period of exposure is longer.

11 Specifically, 100 hours of mean monthly lifetime exposure above 35 °C increases the stunting rate by 5.9 percentage points.

12 In the humanitarian shelter sector, most of the work on shelter and temperature has concentrated on the effects of cold, rather than heat [111].

13 The maximum temperature in Mopti, Mali (before counting the additional stress from humidity) has been above 41 degrees every year since 2010.


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